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THE RADIATION LABORATORY
DEPARTMENT OF ELECTRICAL ENGINEERING

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ATTENTION	T. L. K. Smull, Director Grants and Research Contracts Office of Space Sciences
SUBJECT	Final Report
PERIOD COVERED	1 May 1963 – 31 October 1965
GRANT NO.	NsG-444
GRANT TITLE	Analytical Studies of Relationships Between Far-field Radiation Patterns and Near-field Current Distributions and Surface Configurations, including Consideration of the Effects of Small-vehicle (few wavelengths) on Antenna Performance.
CONTRACT MONITOR	W. F. Croswell, CRS/IRD Langley Research Center Hampton, Virginia 23365

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This is the final report on NASA Grant NsG-444 and covers the entire contract period from 1 May 1963 to 31 October 1965.

The principal results which have been obtained are outlined in the following paragraphs. All the details are to be found in the publications issued under this Grant. A complete list of these publications is given in the Bibliography.

A considerable effort has been directed to the synthesis of a preassigned radiation pattern. A simple launching device for a cylindrical satellite which originates a nearly omnidirectional power pattern over an azimuthal angular range of 100°-120° is described in the Third Semiannual Report on this Grant (Uslenghi 1964a). A theoretical analysis of the extent to which the field at the surface of the cylindrical satellite is specified by a far-field power polar diagram is given by Senior (1964a).

A very detailed investigation of the synthesis problem for an infinite cylindrical conductor with one or more axial or circumferential radiating slots may be found in Einarsson et al (1965), where the areas of similarity and dissimilarity between the plane and cylindrical cases are clearly delineated. In particular, it is established that the completeness relation which holds in the plane case is also valid for the cylindrical case, i.e. any far-field pattern in the azimuthal plane which is square-integrable over the entire real space can be approximated arbitrarily closely in the mean-square sense by a surface field which is square-integrable over an aperture of arbitrary angular width and vanishes outside this aperture. However, a realistic analysis of the problem must involve a constraint on the behavior of the aperture function. Several possible forms of this constraint have been examined and compared, and an optimization procedure has been developed for a single aperture and a pre-scribed power pattern. The technique consists of minimizing the mean-square deviation from a given far-field pattern with an aperture function expressible in terms of a finite set of basis functions and having a fixed value of the stored energy. If the stored energy is to be finite, the basis functions must satisfy the Meixner edge condition at the ends of the aperture. Various numerical results are given for the most restrictive of the constraints examined. Finally, a theoretical study of pattern synthesis by means of arrays of axial, circumferential, and alternating axial and circumferential half-wavelength slots on an infinite metal cylinder is given, together with extensive numerical results.

In order to avoid a large excitation of surface currents and thus obtain a reasonable pattern coverage from a single radiating slot, the slot must be recessed from the surface of the spacecraft. However, when the vehicle is

coated, the advantage of recessing the slot is partially lost and the final pattern could be entirely unacceptable owing to surface and leaky waves which propagate along the coating layer and are reflected at the ends of the spacecraft, thus producing standing waves which are responsible for the lobing structure of the radiation pattern in the axial direction, and which are therefore to be avoided when a pattern as nearly omnidirectional as possible is desired. A detailed study directed to the elimination of these surface waves has been carried out for the case of a recessed annular slot in a metal cylinder coated with a layer of ablating material (Einarsson and Uslenghi, 1965).

Various theoretical studies of the effect of the satellite size and shape on the performance of the antenna have been completed. Exact results can be obtained only for rather simple configurations of the system antenna-spacecraft: for example, the field of a dipole in the presence of a "conical ring" has been discussed by Uslenghi (1966). A study of the scattered field produced by certain irregularities in the boundary of a two-dimensional body, such as discontinuities in curvature and higher order derivatives or small, periodic, smooth corrugations, has been performed by conformal mapping (Hong, 1965). The high-frequency scattering properties of imperfectly conducting cylinders and spheres coated by absorbers and dielectrics have been investigated (Uslenghi, 1964a, 1965b) . The back scattering cross section of long thin dielectric bodies on a metal plate has been derived (Uslenghi, 1965a) whereas some new properties of dielectric lenses may be found in Uslenghi (1964b).

Several new results have been obtained in the field of radiation phenomena in moving media. A closed form of the dyadic Green's function for a moving isotropic medium has been derived by Tai (1965b) and a study of Huygen's principle in moving media is given by Tai (1965a). Tai (1965c) also reported on a first-order theory of electrodynamics of moving anisotropic media.

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